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(54) **ACOUSTIC DEVICE**

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See application file for complete search history.

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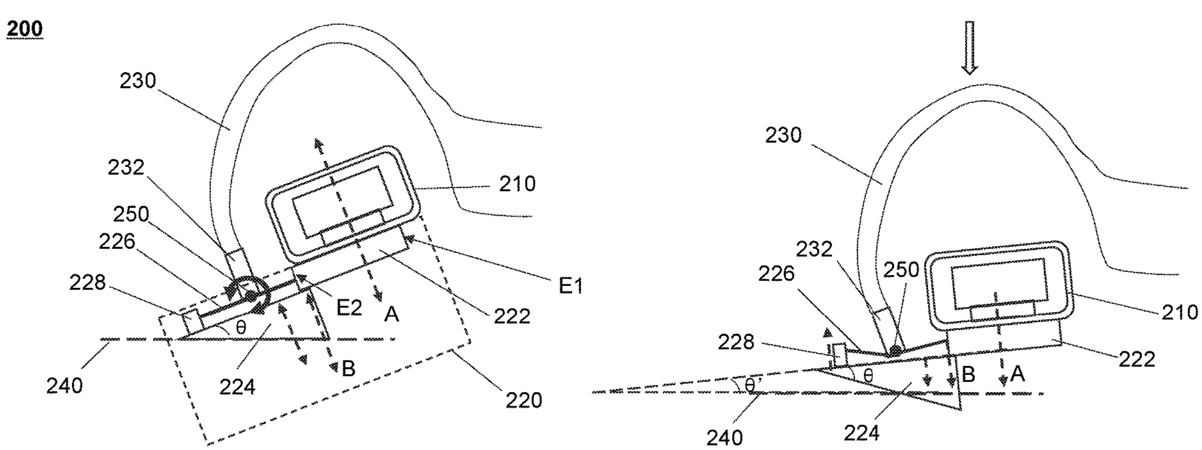
(57) **ABSTRACT**

The present disclosure relates to acoustic devices. The acoustic device may include a vibration speaker, a delivery mechanism mechanically connected to the vibration speaker, and a support component mechanically connected to the vibration speaker via the delivery mechanism. The vibration speaker may be configured to produce a vibration signal representing a sound according to an electrical signal. The delivery mechanism may be configured to contact a user via a contact portion on the delivery mechanism, and deliver the vibration signal to the user via the contact portion. The contact portion on the delivery mechanism may be at a distance from the vibration speaker and have a less vibration intensity than that of the vibration speaker. The support component may be configured to support the delivery mechanism.

20 Claims, 3 Drawing Sheets



(51) **Int. Cl.**

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H04R 7/16	(2006.01)
H04R 9/02	(2006.01)
H04R 9/06	(2006.01)

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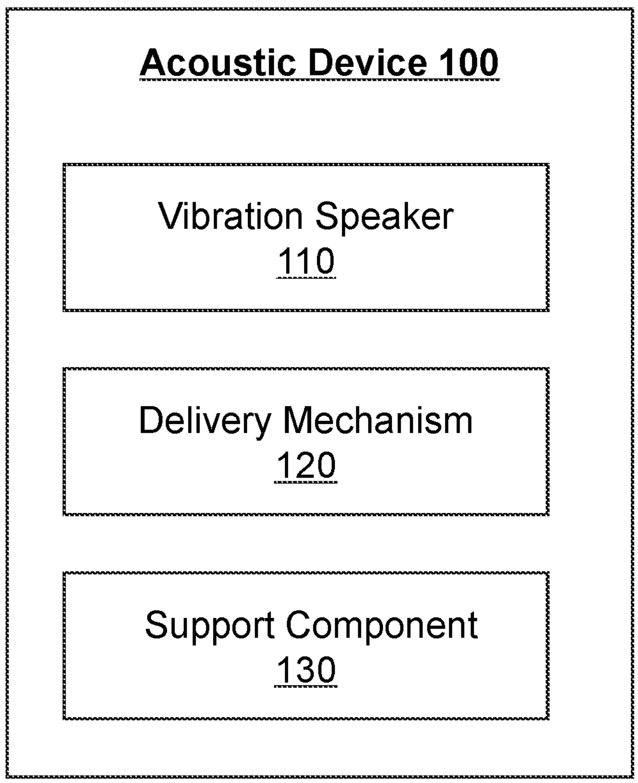
Acoustic Device 100
Vibration Speaker
110
Delivery Mechanism
120
Support Component
130

FIG. 1

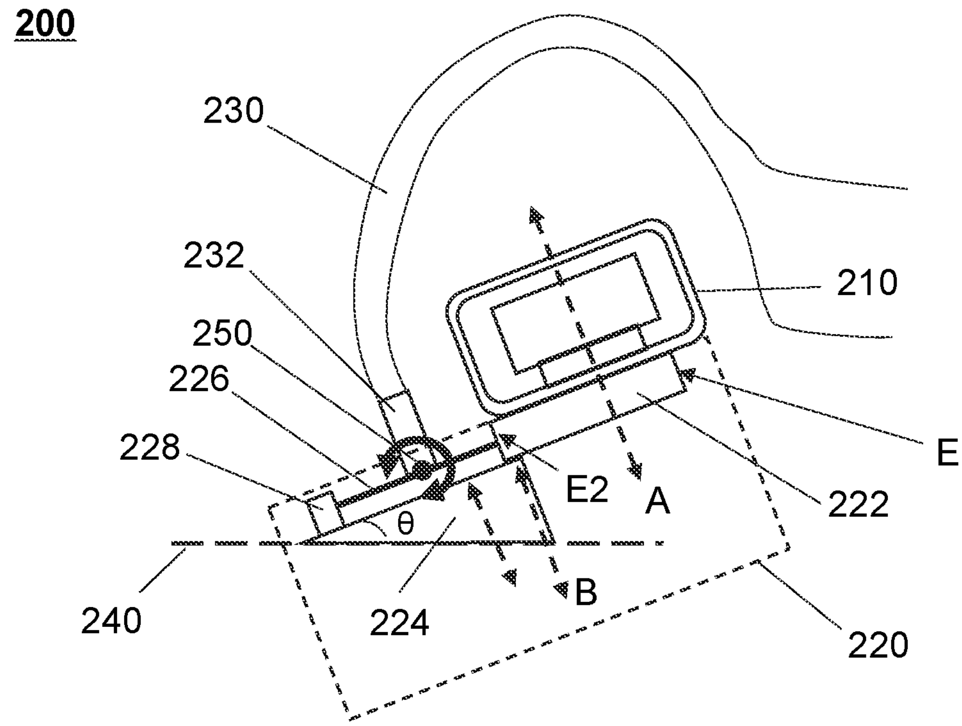
200
230
232
250
226
228
210
E1
E2
A
222
θ
B
240
224
220

FIG. 2A

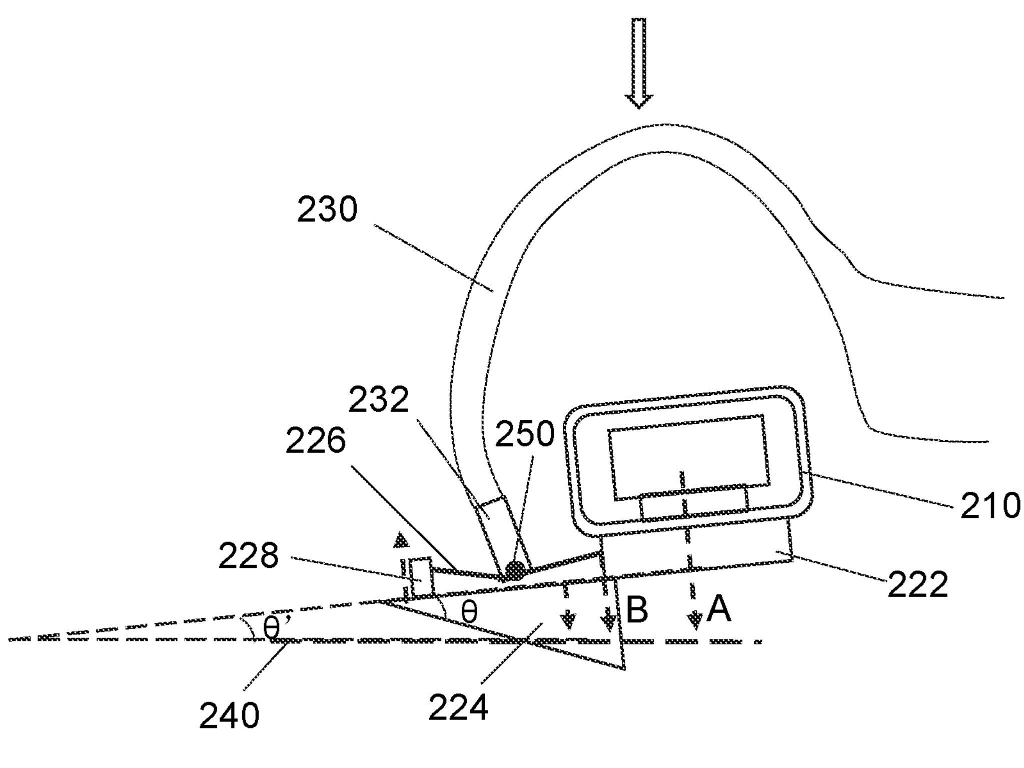
230
232
250
226
210
228
222
θ
B
A
θ'
240
224

FIG. 2B

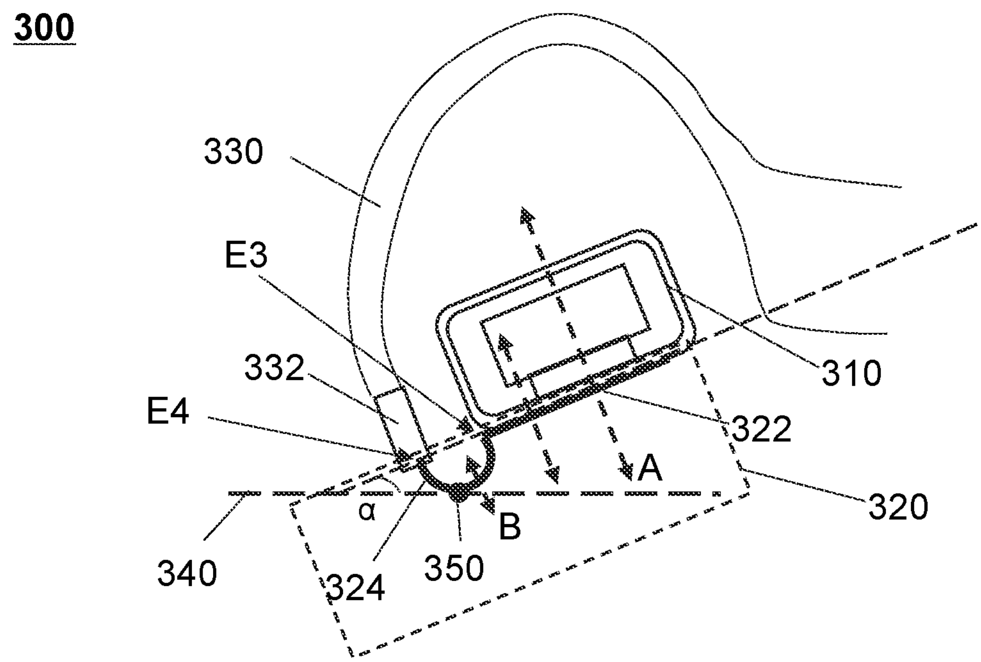
300
330
E3
332
E4
310
322
A
320
α
B
340
324
350

FIG. 3A

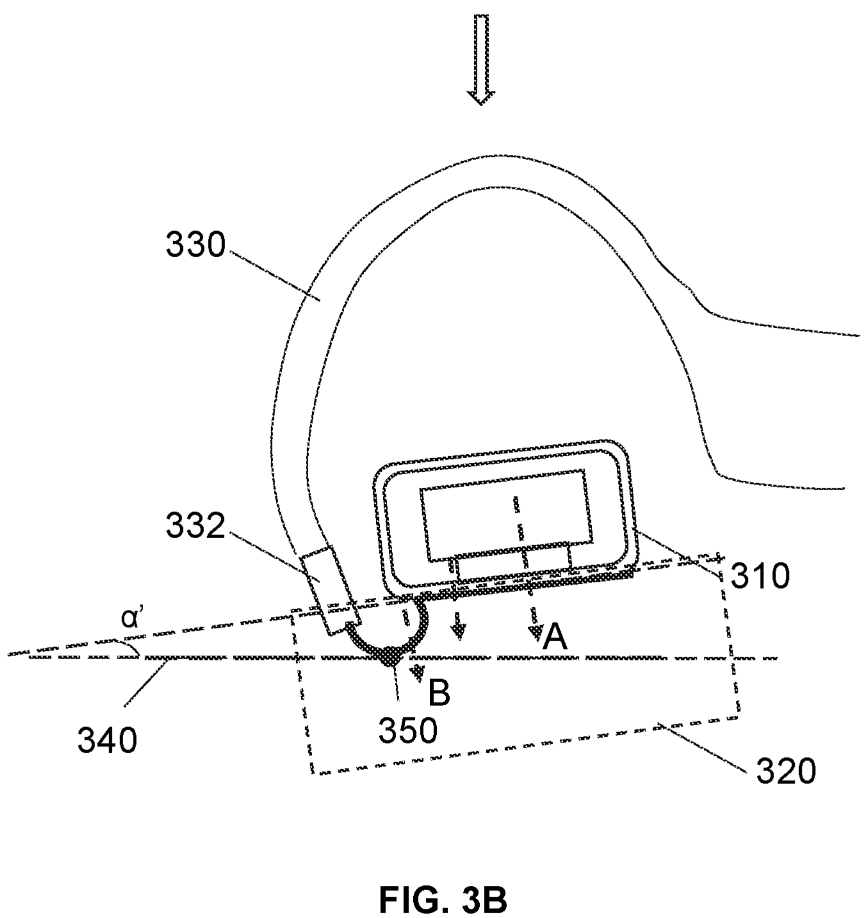
330
332
310
α'
A
B
340
350
320

FIG. 3B

ACOUSTIC DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of International Application No. PCT/CN2020/128525, filed on Nov. 13, 2020, which claims priority of Chinese Patent Application No. 202010247338.2, filed on Mar. 31, 2020, the contents of each of which are hereby incorporated by reference.

TECHNICAL FIELD

The present disclosure generally relates to an acoustic device, and particularly, to an acoustic device with a delivery mechanism.

BACKGROUND

Vibration speakers can convert electrical signals into mechanical vibration signals, and transmit the mechanical vibration signals to a user through human tissues and/or bones so that the user can hear sounds. Generally, when a vibration speaker outputs low-frequency vibration signals to the user via a direct contact with the user, the user may feel a strong sense of vibration, which may cause an uncomfortable experience to the user. It is desirable to provide vibration speakers that have abundant low-frequency signals and can also improve user experience.

SUMMARY

According to an aspect of the present disclosure, an acoustic device is provided. The acoustic device may include a vibration speaker configured to produce a vibration signal representing a sound according to an electrical signal. The acoustic device may further include a delivery mechanism mechanically connected to the vibration speaker. The delivery mechanism may be configured to contact a user via a contact portion on the delivery mechanism and deliver the vibration signal to the user via the contact portion. The contact portion on the delivery mechanism may be at a distance from the vibration speaker and have a less vibration intensity than that of the vibration speaker. The acoustic device may further include a support component mechanically connected to the vibration speaker via the delivery mechanism. The support component may be configured to support the delivery mechanism.

In some embodiments, the delivery mechanism may include an elastic element. The elastic element may include at least one arc portion.

In some embodiments, a first end of the at least one arc portion may be mechanically connected to the support component and a second end of the at least one arc portion may be mechanically connected to the vibration speaker directly or via a connection portion. The contact portion of the delivery mechanism may be on the at least one arc portion, and the vibration speaker may vibrate around the contact portion in response to the vibration signal.

In some embodiments, a contact area between the delivery mechanism and the user may change in response to the vibration signal.

In some embodiments, the delivery mechanism may include a connection unit, a vibration plate, and an elastic element. The vibration speaker may be mechanically connected to a first end of the connection unit. The vibration plate may be mechanically connected to a second end of the connection unit. The support component may be connected to the connection unit via the elastic element. The vibration speaker may vibrate around a connection point between the support component and the elastic element in response to the vibration signal.

In some embodiments, a surface of the vibration speaker may face an ear canal of the user when the user wears the acoustic device.

In some embodiments, the vibration speaker may include one or more openings configured to transmit air conduction waves generated inside a housing of the vibration speaker to the user. The one or more openings may be arranged toward an ear canal of the user when the user wears the acoustic device.

In some embodiments, the acoustic device may further include an auxiliary support component directly connected to the vibration speaker. The auxiliary support component may be configured to support the vibration speaker.

In some embodiments, an angle between the delivery mechanism and a plane where the user's skin is located may be in an angle range from 0° to 90°, or from 0° to 70°, or from 5° to 50°, or from 10° to 50°, or from 10° to 30°.

In some embodiments, a lowest resonance peak of the vibration speaker is less than 90 Hz.

In some embodiments, the vibration speaker may include a magnetic circuit component, a vibration component, and a housing. The lowest resonance peak of the vibration speaker may be related to an elastic moduli of the vibration component of the vibration speaker.

In some embodiments, the support component may include a fixing portion, the fixing portion may have a U-shape or a C-shape.

In some embodiments, the support component may include a shell structure with a hollow interior, the hollow interior may accommodate at least one of a battery, a Bluetooth device, or a circuit board.

According to another aspect of the present disclosure, an electronic device is provided. The electronic device may comprise an acoustic device. The acoustic device may include a vibration speaker configured to produce a vibration signal representing a sound according to an electrical signal. The acoustic device may further include a delivery mechanism mechanically connected to the vibration speaker. The delivery mechanism may be configured to contact a user via a contact portion on the delivery mechanism and deliver the vibration signal to the user via the contact portion. The contact portion on the delivery mechanism may be at a distance from the vibration speaker and have a less vibration intensity than that of the vibration speaker. The acoustic device may further include a support component mechanically connected to the vibration speaker via the delivery mechanism. The support component may be configured to support the delivery mechanism.

Additional features will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following and the accompanying drawings or may be learned by production or operation of the examples. The features of the present disclosure may be realized and attained by practice or use of various aspects of the methodologies, instrumentalities, and combinations set forth in the detailed examples discussed below.

BRIEF DESCRIPTION OF THE DRAWINGS

The present disclosure is further described in terms of exemplary embodiments. These exemplary embodiments are described in detail with reference to the drawings. These embodiments are non-limiting exemplary embodiments, in which like reference numerals represent similar structures throughout the several views of the drawings, and wherein:

FIG. **1** is a block diagram illustrating an exemplary acoustic device according to some embodiments of the present disclosure;

FIGS. **2**A and **2**B illustrate an initial state and an intermediate state of an exemplary acoustic device during a vibration signal delivering process according to some embodiments of the present disclosure; and

FIGS. **3**A and **3**B illustrate an initial state and an intermediate state of an exemplary acoustic device during a vibration signal delivering process according to some embodiments of the present disclosure.

DETAILED DESCRIPTION

The following description is presented to enable any person skilled in the art to make and use the present disclosure and is provided in the context of a particular application and its requirements. Various modifications to the disclosed embodiments will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the present disclosure. Thus, the present disclosure is not limited to the embodiments shown but is to be accorded the widest scope consistent with the claims.

The terminology used herein is for the purpose of describing particular example embodiments only and is not intended to be limiting. As used herein, the singular forms "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes," and/or "including" when used in this disclosure, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

These and other features, and characteristics of the present disclosure, as well as the methods of operations and functions of the related elements of structure and the combination of parts and economies of manufacture, may become more apparent upon consideration of the following description with reference to the accompanying drawing(s), all of which form part of this specification. It is to be expressly understood, however, that the drawing(s) is for the purpose of illustration and description only and are not intended to limit the scope of the present disclosure. It is understood that the drawings are not to scale.

It will be understood that, although the terms "first," "second," "third," etc., may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element, without departing from the scope of exemplary embodiments of the present disclosure.

Spatial and functional relationships between elements are described using various terms, including "connected," "attached," and "mounted." Unless explicitly described as being "direct," when a relationship between first and second elements is described in the present disclosure, that relationship includes a direct relationship where no other intervening elements are present between the first and second elements, and also an indirect relationship where one or more intervening elements are present (either spatially or functionally) between the first and second elements. In contrast, when an element is referred to as being "directly" connected, attached, or positioned to another element, there are no intervening elements present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between," versus "directly between," "adjacent," versus "directly adjacent").

It should also be understood that terms such as "top," "bottom," "upper," "lower," "vertical," "lateral," "above," "below," "upward(s)," "downward(s)," "left-hand side," "right-hand side," "left," "right," "horizontal," and other such spatial reference terms are used in a relative sense to describe the positions or orientations of certain surfaces/parts/components of the acoustic device with respect to other such features of the acoustic device when the acoustic device is in a normal operating position and may change if the position or orientation of the acoustic device changes.

An aspect of the present disclosure relates to an acoustic device. The acoustic device may include a vibration speaker, a delivery mechanism, and a support component. The vibration speaker may be configured to produce a vibration signal representing a sound according to an electrical signal. The delivery mechanism may be mechanically connected to the vibration speaker. The delivery mechanism may be configured to contact a user via a contact portion on the delivery mechanism and deliver the vibration signal to the user via the contact portion. The contact portion on the delivery mechanism may be at a distance from the vibration speaker and have a less vibration intensity than that of the vibration speaker. The support component may be mechanically connected to the vibration speaker via the delivery mechanism. The support component may be configured to support the delivery mechanism.

In some embodiments, a contact area between the contact portion of the delivery mechanism and the user may change in response to the vibration signal. During a vibration signal delivering process, when the vibration speaker vibrates toward the user, the contact area between the contact portion of the delivery mechanism and the user (or user's skin) can be decreased gradually, which is smaller than a contact area when the vibration speaker directly contacts the user normally, thereby further reducing the vibration sensation of the user. In addition, since the contact portion of the delivery mechanism has a less vibration intensity than that of the vibration speaker, the vibration intensity of the vibration signal delivered to the user by the delivery mechanism may be reduced, thereby further reducing the vibration sensation of the user.

In some alternative embodiments, the delivery mechanism may be an elastic element with an arc portion, thus the contact area between the contact portion of the delivery mechanism and the user may not change (or substantially not change) in response to the vibration signal. During a vibration signal delivering process, when the vibration speaker vibrates toward the user, part of the vibration signal generated by the vibration speaker can be converted into elastic deformation of the elastic element. Thus, the vibration sensation of the user may be smaller than a vibration sensation of the user in which the vibration speaker directly contacts the user.

Moreover, the vibration speaker may be arranged such that a surface of the vibration speaker faces an ear canal of the user. In this way, when the vibration speaker vibrates toward the user, the vibration speaker can drive the air around the vibration speaker to vibrate and transmit sound signal(s) to the user through the air, thereby enhancing sound intensity delivered to the user. As a result, the vibration speaker can be designed to provide deeper low-frequency signals such that the sound energy at the low-frequency range gets more abundant, thereby strengthening the feeling of users for sound (e.g., music) in low-frequency signals and allowing the users to feel more low-frequency effects.

FIG. **1** is a block diagram illustrating an exemplary acoustic device according to some embodiments of the present disclosure. For example, the acoustic device **100** may be an acoustic device of an electronic device, such as an earphone, a headphone, a virtual reality glasses, an augmented reality glasses, etc. As illustrated in FIG. **1**, the acoustic device **100** may include a vibration speaker **110**, a delivery mechanism **120**, and a support component **130**. The vibration speaker **110** may be connected to the support component **130** via the delivery mechanism **120**.

The vibration speaker **110** may be configured to produce vibration signal(s) representing a sound according to electrical signal(s). The electrical signal(s) may contain sound information. The sound information may refer to a video file or an audio file with a specific data format, and may also refer to general data or a file which may be converted to sound through specific approaches eventually. The electrical signal(s) may be received from a signal source such as a microphone, a computer, a mobile phone, an MP3 player, etc. For example, a microphone may receive sound signal(s) from a sound source. Then the microphone may convert the received sound signal(s) into the electrical signal(s) and transmit the electrical signal(s) to the vibration speaker **110**. As another example, the vibration speaker **110** may be connected to or communicated with an MP3 player, the MP3 player may directly transmit the electrical signal(s) to the vibration speaker **110**. In some embodiments, the vibration speaker **110** may be connected to and/or communicated with the signal source via a wired connection, a wireless connection, or a combination thereof. The wired connection may include, for example, an electrical cable, an optical cable, a telephone wire, or the like, or any combination thereof. The wireless connection may include a Bluetooth™ network, a local area network (LAN), a wide area network (WAN)), a near field communication (NFC) network, a ZigBee™ network, or the like, or any combination thereof.

In some embodiments, the vibration speaker **110** may be a bone conduction speaker. In some embodiments, the vibration speaker **110** may be a composite speaker. In such cases, the vibration speaker **110** may produce bone conduction waves and air conduction waves that can both be perceived by the user wearing it. It should be noted that the vibration speaker **110** may be of various types, such as an electromagnetic type (e.g., a moving-coil type, a moving-iron type, etc.), a piezoelectric type, an inversed piezoelectric type, an electrostatic type, etc., which is not limited in the present disclosure.

The delivery mechanism **120** may be mechanically connected to the vibration speaker **110**. Thus, the delivery mechanism **120** may receive the vibration signal(s) from the vibration speaker **110**. When the acoustic device **100** is worn on a user, an angle between the delivery mechanism **120** and the user may be formed. As used herein, the angle between the delivery mechanism **120** and the user refers to an angle between the long axis of the delivery mechanism **120** and a plane where the user's skin is located. In some embodiments, the angle may be in an angle range from 0 to 90°, or from 0° to 70°, or from 5° to 50°, or from 10° to 50°, or from 10° to 30°, etc.

The delivery mechanism **120** may be configured to contact a user via a contact portion on the delivery mechanism **120** and deliver the received vibration signal(s) to the user via the contact portion. In some embodiments, a contact area between the delivery mechanism **120** and the user (e.g., user's skin) may change in response to the vibration signal(s). In some embodiments, a region of the user's body that the contact portion on the delivery mechanism **120** is positioned at and/or contacted with may include the forehead, the neck (e.g., the throat), the face (e.g., an area around the mouth, the chin), the top of the head, a mastoid, an area around an ear, a temple, or the like, or any combination thereof.

The contact portion on the delivery mechanism **120** may be at a distance from the vibration speaker **110**. The vibration speaker **110** may vibrate around a rotation axis near the contact portion of the delivery mechanism **120**. In such cases, the contact portion on the delivery mechanism **120** may be closer to the rotation axis than that of the vibration speaker **110**. Thus, the contact portion on the delivery mechanism **120** may have a less vibration intensity than that of the vibration speaker **110**, thereby reducing the vibration transmitted to the user. For example, the delivery mechanism **120** may include an elastic element having at least one arc portion. The contact portion of the delivery mechanism **120** may be on the convex part of the at least one arc portion. The vibration speaker **110** may vibrate around the contact portion in response to the vibration signal(s). More descriptions about the arc portion may be found elsewhere in the present disclosure (e.g., FIG. **3**A and the descriptions thereof). As another example, the delivery mechanism **120** may include a connection unit, a vibration plate, and an elastic element. The vibration speaker **110** may be disposed on an upper surface of the connection unit and the vibration plate may be connected to one end of the connection unit. The contact portion of the delivery mechanism **120** may be on the vibration plate The support component **130** may be connected to the connection unit or the vibration plate via the elastic element. The vibration speaker **110** may vibrate around a connection point between the support component **130** and the elastic element in response to the vibration signal(s). More descriptions about the delivery mechanism with a connection unit, a vibration plate, and an elastic element may be found elsewhere in the present disclosure (e.g., FIG. **2**A and the descriptions thereof).

In some embodiments, the contact portion of the delivery mechanism **120** may be positioned at a region around the ear, in which the vibration speaker **110** can be arranged such that a surface of the vibration speaker **110** faces an ear canal of the user. In this way, when the vibration speaker vibrates, the vibration speaker **110** may drive the air around the vibration speaker to vibrate and produce air conduction waves. The air conduction waves may be transmitted to the ear through air, thereby enhancing sound intensity delivered to the user. Accordingly, the user may not only hear the bone conduction waves generated by the vibration of the contact portion of the delivery mechanism **120**, but also hear the air conduction waves generated by the vibration speaker **110** driving the surrounding air.

In some alternative embodiments, the housing of the vibration speaker **110** may include one or more openings at, e.g., the sidewall of the housing, or the side facing the ear canal of the user. In this way, when the vibration speaker **110** vibrates, air conduction waves generated inside the housing of the vibration speaker **110** (e.g., by the vibration of a vibration component inside the housing) may be transmitted outside the housing through the one or more openings and further transmitted to the user's ear. In some embodiments, the one or more openings of the vibration speaker **110** can be arranged toward the ear canal of the user when the user wears the acoustic device **100**. Accordingly, the user may further hear the air conduction waves transmitted by the one or more openings of the vibration speaker **110**, thereby enhancing the sound intensity heard by the user.

The support component **130** may be mechanically connected to the vibration speaker **110** via the delivery mechanism **120**. The support component **130** may be configured to support the delivery mechanism **120** and/or the vibration speaker **110** so that the delivery mechanism **120** can contact the user's skin.

In some embodiments, the support component **130** may include a fixing portion which allows the acoustic device **100** to be better fixed on the user, and prevent falling off during use by the user. In some embodiments, the fixing portion may have any shape suitable for a part (e.g., the ear, the head, the neck) of human body, for example, a U-shape, a C-shape, a circular ring shape, an ellipse shape, a semi-circular shape, etc., so that the acoustic device **100** may be independently worn on the user's body. For example, the shape of the fixing portion of the support component **130** may match the shape of the human auricle, so that the acoustic device **100** can be independently worn on the user's ear. As another example, the shape of the fixing portion of the support component **130** may match the shape of the human head, so that the support component **130** can be hung on the user's head, which prevents the acoustic device **100** from falling off easily.

In some embodiments, the support component **130** may be a shell structure with a hollow interior. The hollow interior may hold a battery, a circuit board, a Bluetooth device, or the like, or any combination thereof. In some embodiments, the support component **130** may be made of various materials such as metal materials (e.g., aluminum, gold, copper, etc.), alloy materials (e.g., aluminum alloys, titanium alloys, etc.), plastic materials (e.g., polyethylene, polypropylene, epoxy resin, nylon, etc.), fiber materials (e.g., acetate fiber, propionic acid fiber, carbon fiber, etc.), etc. In some embodiments, the support component **130** may be provided with a sheath. The sheath may be made of soft materials with certain elasticity, such as soft silica gel, rubber, etc. which can provide better touch for users.

It should be noted that the above descriptions of the acoustic device **100** is merely provided for the purposes of illustration, and not intended to limit the scope of the present disclosure. For persons having ordinary skills in the art, multiple variations and modifications may be made under the teachings of the present disclosure. However, those variations and modifications do not depart from the scope of the present disclosure. In some embodiments, the connection between any two components (e.g., the vibration speaker **110**, the delivery mechanism **120**, and the support component **130**) of the acoustic device **100** may include bonding, riveting, thread connection, integral forming, suction connection, or the like, or any combination thereof.

In some embodiments, the acoustic device **100** may further include an auxiliary support component configured to assist the support component **130** to support the vibration speaker **110** by contacting the user. The auxiliary support component may have a rod-like structure and an end of the auxiliary support component may be directly connected to the vibration speaker **110**. Accordingly, when the user wears the acoustic device **100**, the auxiliary support component may be in contact with the user and the vibration speaker **110** such that the vibration speaker **110** can transmit a portion of the vibration signal(s) to the user through the auxiliary support component, thereby further enhancing the sound intensity heard by the user.

FIGS. **2**A and **2**B illustrate an initial state and an intermediate state of an exemplary acoustic device during a vibration signal delivering process according to some embodiments of the present disclosure. As shown in FIG. **2**A, an acoustic device **200** may include a vibration speaker **210**, a delivery mechanism **220** (components in dotted frame **220**), and a support component **230**.

The vibration speaker **210** may be connected to the support component **230** via the delivery mechanism **220**. The vibration speaker **210** may generate vibration signal(s) representing a sound according to electrical signal(s). Merely by way of example, the vibration speaker **210** may include a magnetic circuit component, a vibration component, and a housing. The magnetic circuit component may be configured to provide a magnetic field. The vibration component may convert an electrical signal inputted into the vibration component to a mechanical vibration signal in the magnetic field. The housing may include a panel facing a human body side and a back opposite to the panel. The housing may accommodate the vibration component. In some embodiments, the vibration component may cause the panel and the back to vibrate. The vibration speaker **210** may provide various resonance peaks. In some embodiments, the vibration speaker **210** may provide one or more low-frequency resonance peaks in the frequency range of less than 500 Hz, or in the frequency range of less than 800 Hz, or in the frequency range of less than 1000 Hz. The low-frequency resonance peak(s) may be related to the elastic moduli of the vibration component. The less the elastic moduli of the vibration component, the lower the low-frequency resonance peak of the vibration speaker **210** may be.

The delivery mechanism **220** may deliver the vibration signal(s) to a user (e.g., the user's cochlea) by contacting the user. In some embodiments, the delivery mechanism **220** may include a connection unit **222**, a vibration plate **224**, and an elastic element **226**. A contact portion on the delivery mechanism **220** that contacts the user may be on the vibration plate **224**.

In some embodiments, the connection unit **222** may be a structure having two ends (e.g., a first end E**1** and a second end E**2**). For example, the connection unit **222** may be a rod-like structure, a sheet-like structure, etc., having two ends. The vibration speaker **210** may be connected to the vibration plate **224** via the connection unit **222**. For example, a sidewall (e.g., the lower sidewall) of the vibration speaker **210** may be connected to a side wall (e.g., the upper sidewall) of the connection unit **222**. Optionally, the vibration speaker **210** may be disposed on the upper side or connected to the first end E**1** of the connection unit **222**. For example, when the connection unit **222** is a rectangular rod, the vibration speaker **210** may be disposed on the upper sidewall of the connection unit **222** as illustrated in FIG. **2**A. For brevity, the upper side of the connection unit **222** refers to the side of the connection unit **222** that faces away from the user's skin, and the lower side of the connection unit **222** refers to the side of the connection unit **222** that faces towards the user's skin. Similarly, the upper side of the vibration speaker **210** refers to the side of the vibration speaker **210** that faces away from the user's skin, and the lower side of the vibration speaker **210** refers to the side of the vibration speaker **210** that faces towards the user's skin. In some embodiments, when the connection unit **222** is a rod structure, a cross-section of the rod may be of any other shape, such as a rectangle, a triangle, a circle, an ellipse, a regular hexagon, an irregular shape, etc. In some embodiments, when the connection unit **222** is a sheet, the shape of the sheet may include a rectangle, an ellipse, an irregular shape, etc.

The vibration plate **224** may be connected to the lower side of the connection unit **222** at the second end E**2**. The vibration plate **224**, as well as the contact portion on the delivery mechanism **220**, may be at a distance from the vibration speaker **210**. The vibration plate **224** may be configured to contact the user (as illustrated in FIG. **2**A, the dotted line **240** may be roughly regarded as the skin of the user) to deliver the vibration signal(s) to the user. In some embodiments, the vibration plate **224** may be a block such as a wedge-shaped block, which may allow or cause the vibration speaker **210** to be suspended above the skin of the user, thus forming an angle (e.g., **8** in FIG. **2**A) between the upper surface or lower surface of the connection unit **222** and the surface of the user's skin. In some embodiments, the angle between the upper surface or lower surface of the connection unit **222** and the surface of the user's skin may be in a range from 0 to 90°, or from 0° to 70°, or from 5° to 50°, or from 10° to 50°, or from 10° to 30°, etc. In some embodiments, the angle between the upper surface or lower surface of the connection unit **222** and the surface of the user's skin may also be referred to as an angle between the delivery mechanism **220** and the user's skin **240** (or a plane where the user's skin is located).

The elastic element **226** and the vibration plate **224** may be located on the same end of the connection unit **222**, i.e., the elastic element **226** may also be connected to the second end E**2** of the connection unit **222**. An upper surface of the vibration plate **224** may be provided with a convex structure **228** (as illustrated in FIG. **2**A). Two ends of the elastic element **226** may be respectively connected to the convex structure **228** and the second end E**2** of the connection unit **222**. In some embodiments, the elastic element **226** may be a sheet-like structure or a rod-like structure with a certain elasticity.

A first end of the support component **230** may be connected with the elastic element **226** at any point (e.g., a center point) of the elastic element **226**. In some embodiments, the first end of the support component **230** may be connected to the elastic element **226** directly or via a connection element **232**. For example, the first end of the support component **230** may be connected to the center of the elastic element **226** directly or via the connection element **232**. When the acoustic device **200** is fixedly worn on the user, the support component **230** may be regarded as to be stationary with respect to the user, and in such cases, the vibration speaker **210** may drive the connection unit **222** and the vibration plate **224** to rotate around a specific connection point **250** (e.g., the center point of the elastic element **226**) between the support component **230** and the elastic element **226** in response to the vibration signal(s).

According to FIGS. **2**A and **2**B, FIG. **2**A represents an initial state of the acoustic device **200** during a vibration signal delivering process, and FIG. **2**B represents an intermediate state of the acoustic device **200** during the vibration signal delivering process. Arrow A denotes a vibration direction of the vibration speaker **210** and the length of the arrow A denotes the vibration intensity.

When the acoustic device **200** is in the initial state (FIG. **2**A), the angle between the delivery mechanism **220** and the user's skin **240** has a value equal to 0, and at this time, a contact area between the vibration plate **224** and the user's skin **240** is the largest in the vibration signal delivering process. When the acoustic device **200** is in the intermediate state (FIG. **2**B), an angle between the delivery mechanism **220** and the user's skin **240** may be smaller than the angle between the delivery mechanism **220** and the user's skin **240** in the initial state of the acoustic device **200**. Accordingly, a contact area between the delivery mechanism **220** and the user's skin **240** may change in response to the vibration signal(s). For example, during a process that the vibration speaker **210** vibrates around the specific connection point **250** towards the user's skin **240**, the angle between the delivery mechanism **220** and the user's skin **240** may decrease gradually (i.e., θ'<θ in FIG. **2**B). In such cases, a contact area between the vibration plate **224** and the user's skin **240** in the intermediate state of the acoustic device **200** may be less than a contact area between the vibration plate **224** and the user's skin **240** in the initial state of the acoustic device **200**. As a result, during the process that the vibration speaker **210** delivering vibration signal(s) to the user, the vibration sensation of the user may be reduced.

Moreover, since the vibration plate **224** is at a distance from the vibration speaker **210**, and a distance from the vibration plate **224** to the specific connection point **250** is smaller than a distance from the vibration speaker **210** to the specific connection point **250**, during the vibration signal delivering process, the vibration plate **224** may have a less vibration intensity than that of the vibration speaker **210**, thereby further reducing the vibration sensation of the user. Merely by way of example, arrow B denotes the vibration of a point on the contact portion and the length of the arrow B denotes the vibration intensity of the point. Since the perpendicular distance from the specific connection point **250** to arrow B is less than the perpendicular distance from the specific connection point **250** to arrow A, the vibration intensity of arrow A (i.e., the length of arrow A) may be greater than the vibration intensity of arrow B (i.e., the length of arrow B).

Accordingly, by using the delivery mechanism **220**, the vibration originating from the vibration speaker **210** may be reduced, protecting the user from uncomfortable vibration sensation in a low-frequency range. On this basis, the frequency response of the vibration speaker **210** can be more flexibly designed to adapt to different needs. For example, the lowest resonance peak of the vibration speaker **210** may be moved to a lower frequency range to provide more abundant low-frequency signals to the user. As described above, the lowest resonance peak of the vibration speaker **210** may be adjusted by changing the elastic moduli of the vibration component of the vibration speaker **210**. In some embodiments, the elastic moduli of the vibration component of the vibration speaker **210** may be designed such that the lowest resonance peak of the vibration speaker **210** may be less than 2500 Hz, or less than 2000 Hz, or less than 1500 Hz, or less than 1200 Hz, or less than 1000 Hz, or less than 800 Hz, or less than 500 Hz, or less than 300 Hz, or less than 200 Hz, or less than 100 Hz, or less than 90 Hz, or less than 50 Hz.

It should be noted that the above description is merely provided for the purposes of illustration, and not intended to limit the scope of the present disclosure. For persons having ordinary skills in the art, multiple variations and modifications may be made under the teachings of the present disclosure. However, those variations and modifications do not depart from the scope of the present disclosure. For example, the vibration speaker **210** may be connected to the vibration plate **224** directly, i.e., the connection unit **222** may be omitted. In such cases, the elastic element **226** may be directly connected to the vibration speaker **210**. As another example, the acoustic device **200** may further include one or more additional components, such as an auxiliary support component (not shown). As still an example, the contact portion of the delivery mechanism **220** may be positioned at a region around the ear, in which the vibration speaker **210** can be arranged such that a surface of the vibration speaker **210** can face an ear canal of the user to better transmit air conduction waves to the ear. In some embodiments, the connection between any two components (e.g., the vibration speaker **210**, the connection unit **222**, the vibration plate **224**, the support component **230**, etc.) of the acoustic device **200** may include bonding, riveting, thread connection, integral forming, suction connection, or the like, or any combination thereof.

FIGS. **3**A and **3**B illustrate an initial state and an intermediate state of an exemplary acoustic device during a vibration signal delivering process according to some embodiments of the present disclosure. As illustrated in FIG. **3**A, an acoustic device **300** may be similar to the acoustic device **200** illustrated in FIG. **2**A. The acoustic device **300** may include a vibration speaker **310**, a delivery mechanism **320**, and a support component **330**.

The vibration speaker **310** may be connected to the support component **330** via the delivery mechanism **320**. The vibration speaker **310** may generate vibration signal(s) representing a sound according to electrical signal(s). The vibration speaker **310** may be similar to or same as the vibration speaker **210** illustrated in FIG. **2**A.

The delivery mechanism **320** may include an elastic element. The elastic element may include a connection portion **322** and an arc portion **324**, wherein a first end of the connection portion **322** is connected to a first end E**3** of the arc portion **324**. In some embodiments, the elastic element (e.g., the connection portion **322** and/or the arc portion **324**) may be made of various elastic materials such as metal materials (e.g., aluminum, gold, copper, etc.), alloy materials (e.g., aluminum alloys, titanium alloys, etc.), plastic materials (e.g., polyethylene, polypropylene, epoxy resin, nylon, etc.), fiber materials (e.g., acetate fiber, propionic acid fiber, carbon fiber, etc.), etc.

The vibration speaker **310** may be mechanically connected to the connection portion **322**. For example, when the connection portion **322** is a sheet-like structure, the vibration speaker **310** may be disposed on an upper surface of the connection portion **322**. As another example, when the connection portion **322** is a rod-like structure, the vibration speaker **310** may be disposed on an upper surface of the connection portion **322**, or a sidewall of the vibration speaker **310** may be connected to a second end of the connection portion **322**.

The convex part of the arc portion **324** may be configured to contact with the user's skin **340**, thus the vibration speaker **310** can deliver the vibration signal(s) to the user through the delivery mechanism **320**. In such cases, a contact area between the arc portion **324** and the user's skin **340** may be smaller than that of the contact portion of the delivery mechanism **220** illustrated in FIG. **2**A. The contact area between the delivery mechanism **320** and the user's skin **340** may be almost unchanged in response to the vibration signal(s). The vibration speaker **310** may be suspended on the skin of the user and an angle (e.g., a in FIG. **3**A) between the connection portion **322** and the surface of the user's skin **340** may be formed. In some embodiments, the angle between the connection portion **322** and the surface of the user's skin **340** may be in a range from 0 to 90°, or from 0° to 70°, or from 5° to 50°, or from 10° to 50°, or from 10° to 30°, etc. In some embodiments, the angle between the connection portion **322** and the surface of the user's skin **340** may also be referred to as an angle between the delivery mechanism **320** and the user's skin **340** (or a plane where the user's skin is located).

In some embodiments, the convex part of the arc portion **324** that contacts with the user's skin **340** may also be referred to as a contact portion **350** of the delivery mechanism **320**. The contact portion **350** on the delivery mechanism **320** may be at a distance from the vibration speaker **310**. A second end E**4** of the arc portion **324** may be connected with one end of the support component **330**. When the acoustic device **300** is fixedly worn on the user, the support component **330** may be regarded as to be stationary with respect to the user, and in such cases, the vibration speaker **310** may drive the delivery mechanism **320** (i.e., the elastic element connection portion **322** and the arc portion **324**) to vibrate or rotate around the contact portion **350** in response to the vibration signal(s). In some embodiments, the second end E**4** of the arc portion **324** may be connected to the support component **330** via a connection element **332**.

According to FIGS. **3**A and **3**B, FIG. **3**A represents an initial state of the acoustic device **300** during a vibration signal delivering process, and FIG. **3**B represents an intermediate state of the acoustic device **300** during the vibration signal delivering process. Arrow B denotes a vibration direction of the vibration speaker **310** and the length of the arrow B denotes the vibration intensity.

During the vibration signal delivering process, since a contact area between the arc portion **324** and the user's skin **340** is very small, and the vibration signal(s) generated by the vibration speaker **310** is partially converted into the elastic deformation of the delivery mechanism **320** (e.g., the connection portion **322** and/or the arc portion **324**), the vibration sensation of the user may be reduced compared to the vibration sensation of the user when the vibration speaker **310** directly contacts the user's skin **340**.

Moreover, since the contact portion **350** is at a distance from the vibration speaker **310**, during the vibration signal delivering process, the contact portion **350** may have a less vibration intensity than that of the vibration speaker **310**, thereby further reducing the vibration sensation of the user. Merely by way of example, arrow B denotes the vibration of a point near the contact portion **350** and the length of the arrow B denotes the vibration intensity of the point. Since the perpendicular distance from the contact portion **350** to arrow B is less than the perpendicular distance from the contact portion **350** to arrow A, the vibration intensity of arrow A (i.e., the length of arrow A) may be greater than the vibration intensity of arrow B (i.e., the length of arrow B).

Accordingly, by using the delivery mechanism **320**, the vibration originating from the vibration speaker **310** may be reduced, protecting the user from uncomfortable vibration sensation in a low-frequency range. On this basis, the frequency response of the vibration speaker **310** can be more flexibly designed to adapt to different needs. For example, the lowest resonance peak of the vibration speaker **310** may be moved to a lower frequency range to provide more abundant low-frequency signals to the user. As described above, the lowest resonance peak of the vibration speaker **310** may be adjusted by changing the elastic moduli of a vibration component of the vibration speaker **310**. In some embodiments, the elastic moduli of the vibration component of the vibration speaker **310** may be designed such that the lowest resonance peak of the vibration speaker **310** may be less than 2500 Hz, or less than 2000 Hz, or less than 1500 Hz, or less than 1200 Hz, or less than 1000 Hz, or less than

800 Hz, or less than 500 Hz, or less than 300 Hz, or less than 200 Hz, or less than 100 Hz, or less than 90 Hz, or less than 50 Hz.

Merely for illustration purposes, only one elastic element is described in the acoustic device **300**. However, it should be noted that the acoustic device **300** in the present disclosure may also include multiple elastic elements, and thus the vibration signal(s) may also be jointly delivered by the multiple elastic elements. In some embodiments, the elastic element **320** may include multiple arc portions and thus the vibration signal(s) may also be jointly delivered by the multiple arc portions. For example, the multiple arc portions may be arranged side by side.

It should be noted that the above description is merely provided for the purposes of illustration, and not intended to limit the scope of the present disclosure. For persons having ordinary skills in the art, multiple variations and modifications may be made under the teachings of the present disclosure. However, those variations and modifications do not depart from the scope of the present disclosure. For example, the arc portion **324** may be connected to the vibration speaker **310** directly, i.e., the connection portion **322** may be omitted. As another example, the acoustic device **300** may further include one or more additional components, such as an auxiliary support component (not shown). As still another example, the contact portion **350** of the delivery mechanism **320** may be positioned at a region around the ear, in which the vibration speaker **310** can be arranged such that a surface of the vibration speaker **310** can face an ear canal of the user to better transmit air conduction waves to the ear. In some embodiments, the connection between any two components (e.g., the vibration speaker **310**, the arc portion **324**, the connection portion **322**, the support component **330**, etc.) of the acoustic device **300** may include bonding, riveting, thread connection, integral forming, suction connection, or the like, or any combination thereof.

Having thus described the basic concepts, it may be rather apparent to those skilled in the art after reading this detailed disclosure that the foregoing detailed disclosure is intended to be presented by way of example only and is not limiting. Various alterations, improvements, and modifications may occur and are intended to those skilled in the art, though not expressly stated herein. These alterations, improvements, and modifications are intended to be suggested by this disclosure and are within the spirit and scope of the exemplary embodiments of this disclosure.

Moreover, certain terminology has been used to describe embodiments of the present disclosure. For example, the terms "one embodiment," "an embodiment," and/or "some embodiments" mean that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. Therefore, it is emphasized and should be appreciated that two or more references to "an embodiment," "one embodiment," or "an alternative embodiment" in various portions of this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures or characteristics may be combined as suitable in one or more embodiments of the present disclosure.

Further, it will be appreciated by one skilled in the art, aspects of the present disclosure may be illustrated and described herein in any of a number of patentable classes or context including any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof. Accordingly, aspects of the present disclosure may be implemented entirely hardware, entirely software (including firmware, resident software, micro-code, etc.) or combining software and hardware implementation that may all generally be referred to herein as a "block," "module," "engine," "unit," "component," or "system." Furthermore, aspects of the present disclosure may take the form of a computer program product embodied in one or more computer readable media having computer readable program code embodied thereon.

A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including electro-magnetic, optical, or the like, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that may communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device. Program code embodied on a computer readable signal medium may be transmitted using any appropriate medium, including wireless, wireline, optical fiber cable, RF, or the like, or any suitable combination of the foregoing.

Computer program code for carrying out operations for aspects of the present disclosure may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Scala, Smalltalk, Eiffel, JADE, Emerald, C++, C#, VB. NET, Python or the like, conventional procedural programming languages, such as the "C" programming language, Visual Basic, Fortran 1703, Perl, COBOL 1702, PHP, ABAP, dynamic programming languages such as Python, Ruby and Groovy, or other programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider) or in a cloud computing environment or offered as a service such as a software as a service (SaaS).

Furthermore, the recited order of processing elements or sequences, or the use of numbers, letters, or other designations, therefore, is not intended to limit the claimed processes and methods to any order except as may be specified in the claims. Although the above disclosure discusses through various examples what is currently considered to be a variety of useful embodiments of the disclosure, it is to be understood that such detail is solely for that purpose, and that the appended claims are not limited to the disclosed embodiments, but, on the contrary, are intended to cover modifications and equivalent arrangements that are within the spirit and scope of the disclosed embodiments. For example, although the implementation of various components described above may be embodied in a hardware device, it may also be implemented as a software-only solution—e.g., an installation on an existing server or mobile device.

Similarly, it should be appreciated that in the foregoing description of embodiments of the present disclosure, various features are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure aiding in the understanding of one or more of the various embodiments. This method of disclosure, however, is not to be interpreted as reflecting an intention that the claimed subject matter requires more features than are expressly recited in each claim. Rather, claimed subject matter may lie in less than all features of a single foregoing disclosed embodiment.

In some embodiments, the numbers expressing quantities or properties used to describe and claim certain embodiments of the application are to be understood as being modified in some instances by the term "about," "approximate," or "substantially." For example, "about," "approximate," or "substantially" may indicate ±20% variation of the value it describes, unless otherwise stated. Accordingly, in some embodiments, the numerical parameters set forth in the written description and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by a particular embodiment. In some embodiments, the numerical parameters should be construed in light of the number of reported significant digits and by applying ordinary rounding techniques. Notwithstanding that the numerical ranges and parameters setting forth the broad scope of some embodiments of the application are approximations, the numerical values set forth in the specific examples are reported as precisely as practicable.

Each of the patents, patent applications, publications of patent applications, and other material, such as articles, books, specifications, publications, documents, things, and/or the like, referenced herein is hereby incorporated herein by this reference in its entirety for all purposes, excepting any prosecution file history associated with same, any of same that is inconsistent with or in conflict with the present document, or any of same that may have a limiting affect as to the broadest scope of the claims now or later associated with the present document. By way of example, should there be any inconsistency or conflict between the descriptions, definition, and/or the use of a term associated with any of the incorporated material and that associated with the present document, the description, definition, and/or the use of the term in the present document shall prevail.

In closing, it is to be understood that the embodiments of the application disclosed herein are illustrative of the principles of the embodiments of the application. Other modifications that may be employed may be within the scope of the application. Thus, by way of example, but not of limitation, alternative configurations of the embodiments of the application may be utilized in accordance with the teachings herein. Accordingly, embodiments of the present application are not limited to that precisely as shown and described.

What is claimed is:

1. An acoustic device, comprising:
- a vibration speaker configured to produce a vibration signal representing a sound according to an electrical signal;
- a delivery mechanism mechanically connected to the vibration speaker, the delivery mechanism being configured to contact a user via a contact portion on the delivery mechanism, and deliver the vibration signal to the user via the contact portion, the contact portion on the delivery mechanism being at a distance from the vibration speaker and having a less vibration intensity than that of the vibration speaker, wherein the delivery mechanism includes an elastic element, and the elastic element includes at least one arc portion; and
- a support component mechanically connected to the vibration speaker via the delivery mechanism, the support component being configured to support the delivery mechanism.

2. The acoustic device of claim 1, wherein a first end of the at least one arc portion is mechanically connected to the support component and a second end of the at least one arc portion is mechanically connected to the vibration speaker directly or via a connection portion, wherein
the contact portion of the delivery mechanism is on the at least one arc portion, and the vibration speaker vibrates around the contact portion in response to the vibration signal.

3. The acoustic device of claim 1, wherein a contact area between the delivery mechanism and the user changes in response to the vibration signal.

4. The acoustic device of claim 1, wherein a surface of the vibration speaker faces an ear canal of the user when the user wears the acoustic device.

5. The acoustic device of claim 1, wherein the vibration speaker includes one or more openings configured to transmit air conduction waves generated inside a housing of the vibration speaker to the user, and the one or more openings are arranged toward an ear canal of the user when the user wears the acoustic device.

6. The acoustic device of claim 1, further comprising:
an auxiliary support component directly connected to the vibration speaker, configured to support the vibration speaker.

7. The acoustic device of claim 1, wherein an angle between the delivery mechanism and a plane where the user's skin is located is in an angle range from 0° to 90°, or from 0° to 70°, or from 5° to 50°, or from 10° to 50°, or from 10° to 30°.

8. The acoustic device of claim 1, wherein a lowest resonance peak of the vibration speaker is less than 90 Hz.

9. The acoustic device of claim 8, wherein the vibration speaker includes a magnetic circuit component, a vibration component, and a housing, and the lowest resonance peak of the vibration speaker is related to an elastic moduli of the vibration component of the vibration speaker.

10. The acoustic device of claim 1, wherein the support component includes a fixing portion, the fixing portion has a U-shape or a C-shape.

11. The acoustic device of claim 10, wherein the support component includes a shell structure with a hollow interior, the hollow interior accommodates at least one of a battery, a Bluetooth device, or a circuit board.

12. An electronic device comprising an acoustic device, wherein the acoustic device includes:
- a vibration speaker configured to produce a vibration signal representing a sound according to an electrical signal;
- a delivery mechanism mechanically connected to the vibration speaker, the delivery mechanism being configured to contact a user via a contact portion on the delivery mechanism, and deliver the vibration signal to the user via the contact portion, the contact portion on the delivery mechanism being at a distance from the vibration speaker and having a less vibration intensity than that of the vibration speaker; and
- a support component mechanically connected to the vibration speaker via the delivery mechanism, the support component being configured to support the delivery mechanism,

wherein the delivery mechanism includes:

a connection unit, wherein the vibration speaker is mechanically connected to a first end of the connection unit;

a vibration plate mechanically connected to a second end of the connection unit; and

an elastic element, wherein the support component is connected to the connection unit via the elastic element, the vibration speaker vibrates around a connection point between the support component and the elastic element in response to the vibration signal.

13. The electronic device of claim **12**, wherein a first end of the at least one arc portion is mechanically connected to the support component and a second end of the at least one arc portion is mechanically connected to the vibration speaker, wherein

the contact portion of the delivery mechanism is on the at least one arc portion, and the vibration speaker vibrates around the contact portion in response to the vibration signal.

14. The electronic device of claim **12**, wherein a contact area between the delivery mechanism and the user changes in response to the vibration signal.

15. The electronic device of claim **12**, wherein a lowest resonance peak of the vibration speaker is less than 90 Hz.

16. The electronic device of claim **12**, wherein the vibration speaker includes a magnetic circuit component, a vibration component, and a housing, and the lowest resonance peak of the vibration speaker is related to an elastic moduli of the vibration component of the vibration speaker.

17. The electronic device of claim **12**, wherein a surface of the vibration speaker faces an ear canal of the user when the user wears the acoustic device.

18. The electronic device of claim **12**, wherein the vibration speaker includes one or more openings configured to transmit air conduction waves generated inside a housing of the vibration speaker to the user, and the one or more openings are arranged toward an ear canal of the user when the user wears the acoustic device.

19. The electronic device of claim **12**, wherein the acoustic device further comprises:

an auxiliary support component directly connected to the vibration speaker, configured to support the vibration speaker.

20. The electronic device of claim **12**, wherein an angle between the delivery mechanism and a plane where the user's skin is located is in an angle range from 0° to 90°, or from 0° to 70°, or from 5° to 50°, or from 10° to 50°, or from 10° to 30°.

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